Gravitational Energy Handout

1. Why is g different at poles than at equator? because

a) Earth is not a perfect sphere, it bulges in the middle

$r_e > r_p$

$g = \frac{GM}{r^2}$

$g_e < g_p$

b) Earth's spin results in masses on the equator having a slightly lower apparent weight due to the centripetal acceleration.
$F_N = F_g - F_c$
you are slightly in freefall.
both factors cause an effect of about 0.03 each
so equator 9.781 and pole is 9.832
about 0.05 N/kg difference

2. $g = a = 4\pi^2 r/T^2 = 4\pi^2(3.43\times10^6)/(102\times60)^2 =$ **3.62N/kg**

3. $a = 4\pi^2 r/T^2 = 4\pi^2(3.9\times10^8)/(27.3\times24\times3600)^2 =$ **2.7×10^{-3} m/s^2**

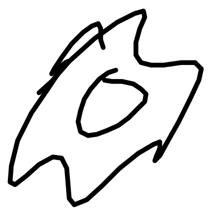
4. $r = 6.38\times10^6$ (height is negligible)
a=g

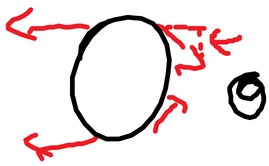
$v^2/r = GM/r^2 = 9.80 m/s^2$

$v = sqrt(9.8x6.38E6) = 7,907.211898008046$

7.9×10^3 m/s

5. $a = 4\pi^2 r/T^2 = 4\pi^2(1.5x10^{11})/(365.25x24x3600)^2 =$
   $= 5.95x10^{-3} m/s^2$
6. Earth to Sun is about double Moon to Earth
   Why does the Moon cause tides more strongly than the Sun?
   Tides are caused by the tangental components of the gravity not the net gravity.
   Since the Moon is closer, it has larger lateral component.





7 ma=mg

a) same b) $v^2/r = GM/r^2$ same c) same d) double

F_c=ma a is same, m is double so Fc is double

8 Eg=-GMm/r = - 6.67E-11x5.98E24x1/6.38E6

=-6.2518E7 = $-6.25x10^7$ J

9. Due to the Earth's gravitational pull
   Egf = -6.67E-11x5.98E24x1/3.9E8=-1.0227E6
   Egf-Egi = -1.0227E6-(-6.2518E7)=61,495,300
   6.1×10^7J

keeners: include the change in gravitational energy due to the moon's pull:
-GMm(1/rf-1/ri)
-6.67E-11x7.35E22x1x((1/1.74E6)-(1/3.8E8))=-2.8046E6

so total is 61,495,300-2.8046E6=58,690,700
5.9×10^7 J

Q10 escape velocity total energy is 0
Eg+Ek = 0
$-GMm/r+1/2mv^2 = 0$
v=sqrt(2GM/r) =
sqrt(2x6.67E-11x7.35E22/1.74E6)=
2,373.815494093844
2.4 km/s

Q11 -GMm/r for Earth and Moon
Earth
-6.67E-11x5.98E24x1000/6.38E6=-6.2518E10
Moon
-6.67E-11x7.35E22x1000/1.74E6=-2.8175E9

6.3×10^{10} J vs 2.8×10^9 J
way less energy -2.8175E9/-6.2518E10=0.0451

about 1/20th of the energy required not including air resistance!

Any questions about the quiz next class?

eg. The moon has a mass of 7.35×10^{22}kg and a radius of 1.77×10^6m. If you are in orbit around the moon at a height of 400km, what is your (if your mass is 50.0kg)

a) gravitational energy in that orbit relative to 0 at infinity?

Eg=-GMm/r

= -6.67E-11x7.35E22x50/(1.77E6+400000)=-1.1296E8

-1.13×10^8J

b) kinetic energy in that orbit?

Ek=1/2 |Eg| = 0.5x1.1296E8=56,480,000

5.65×10^7J

$v^2/r = GM/r^2$

v= sqrt(6.67E-11x7.35E22/(1.77E6+400000))= 1503.061392088526

Ek = 0.5x50x1503.061392088526x1503.0613920885269=5.6479838709677E7

5.65×10^7J

c) total energy?

$E_{total} = 1/2Eg = -5.65 \times 10^7$J

d) escape speed from the surface of the moon.

Eg+Ek = 0

$-GMm/r + 1/2mv^2 =$

v=sqrt(2GM/r) =

sqrt(2x6.67E-11x7.35E22/1.74E6)=
2,373.815494093844
2.4 km/s

e) if you hit a golf ball from the surface of the moon at 1700 m/s, how high would it go?

total energy is conserved

Egi+Eki = Egf+ Ekf

$-GMm/r + 1/2mv^2 = -GMm/rf + 0$

-6.67E-11x7.35E22/1.74E6=-2.8175E6

0.5x(1700)x1700=1445000

1445000-2.8175E6=-1372500 =-GM/rf

rf = -6.67E-11x7.35E22/-1372500=3.5719E6

final radius = 3.57×10^6 m

or final height of 3.5719E6-1.74E6=1.8319E6

of 1.83×10^6 m off the surface of the moon.